Lecture #3

OUTLINE

- Power calculations
- Circuit elements
  - Voltage and current sources
  - Electrical resistance (Ohm's law)
- Kirchhoff's laws

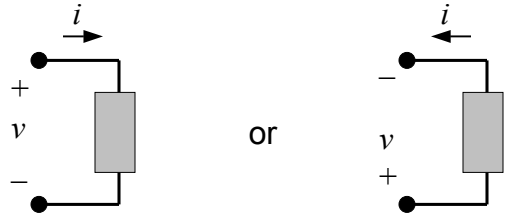
Reading

Chapter 2

Review: Power

If an element is absorbing power (*i.e.* if $p > 0$), positive charge is flowing from higher potential to lower potential.

$\boldsymbol{p = vi}$ if the "passive sign convention" is used:

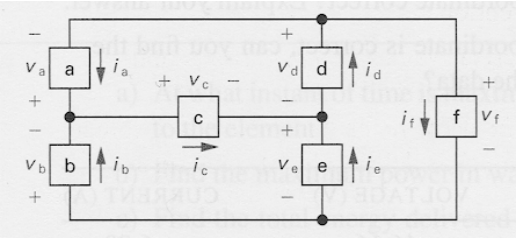


How can a circuit element absorb power?

By converting electrical energy into heat (resistors in toasters), light (light bulbs), or acoustic energy (speakers); by storing energy (charging a battery).

Power Calculation Example

Find the power absorbed by each element:



Conservation of energy
➔ total power delivered equals total power absorbed

ELEMENT	VOLTAGE (V)	CURRENT (A)	*vi* (W)	*p* (W)
a	−18	−51	918	
b	−18	45	- 810	
c	2	−6	- 12	
d	20	−20	- 400	
e	16	−14	- 224	
f	36	31	1116	

Circuit Elements

- There are 5 ideal basic circuit elements:
  - voltage source
  - current source

  } ***active elements***, capable of generating electric energy
  - resistor
  - inductor
  - capacitor

  } ***passive elements***, incapable of generating electric energy
- Many practical systems can be modeled with just sources and resistors
- The basic analytical techniques for solving circuits with inductors and capacitors are the same as those for resistive circuits

Electrical Sources

- An ***electrical source*** is a device that is capable of converting non-electric energy to electric energy and *vice versa*.

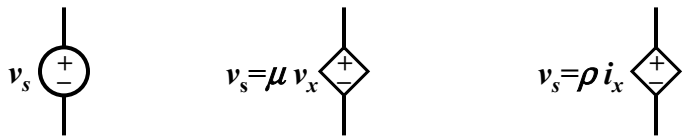
  Examples:
  - battery: chemical ⟷ electric
  - dynamo (generator/motor): mechanical ⟷ electric

→Electrical sources can either deliver or absorb power

Ideal Voltage Source

- Circuit element that maintains a prescribed voltage across its terminals, **regardless of the current flowing in those terminals**.
  - Voltage is known, but current is determined by the circuit to which the source is connected.
- The voltage can be either **independent or dependent** on a voltage or current elsewhere in the circuit, and can be constant or time-varying.

Circuit symbols:

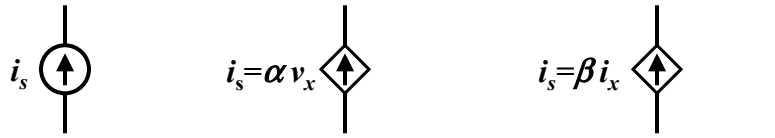


independent **voltage-controlled** **current-controlled**

Ideal Current Source

- Circuit element that maintains a prescribed current through its terminals, **regardless of the voltage across those terminals**.
  - Current is known, but voltage is determined by the circuit to which the source is connected.
- The current can be either **independent or dependent** on a voltage or current elsewhere in the circuit, and can be constant or time-varying.

Circuit symbols:



independent **voltage-controlled** **current-controlled**

Electrical Resistance

- ***Resistance*** is the capacity of a material to impede the flow of electric charge. The circuit element used to model this behavior is the ***resistor***.

Circuit symbol:

Units: Volts per Ampere ≡ ohms (Ω)

- The current flowing in the resistor is proportional to the voltage across the resistor:

$$v = i\,R \qquad \text{(Ohm's Law)}$$

where v = voltage (V), i = current (A), and R = resistance (Ω)

Electrical Conductance

- **Conductance** is the reciprocal of resistance.

  Symbol: G

  Units: **siemens (S) or mhos (℧)**

Example:

Consider an 8 Ω resistor. *What is its conductance?*

Short Circuit and Open Circuit

Wire ("short circuit"):

- $R = 0$ → **no voltage difference exists**
  (all points on the wire are at the same potential)
- Current can flow, as determined by the circuit

Air ("open circuit"):

- $R = \infty$ → **no current flows**
- Voltage difference can exist, as determined by the circuit

Figure 2.10 Circuit symbols. (a) Short circuit. (b) Open circuit. (c) Switch.

Circuit Nodes and Loops

- A ***node*** is a point where two or more circuit elements are connected.
- A ***loop*** is formed by tracing a closed path in a circuit through selected basic circuit elements without passing through any intermediate node more than once

Example:

Kirchhoff's Laws

- **Kirchhoff's Current Law (KCL):**
  - The algebraic sum of all the currents at any node in a circuit equals zero.

- **Kirchhoff's Voltage Law (KVL):**
  - The algebraic sum of all the voltages around any loop in a circuit equals zero.

Example: Power Absorbed by a Resistor

$$p = vi = (iR)i = i^2R$$

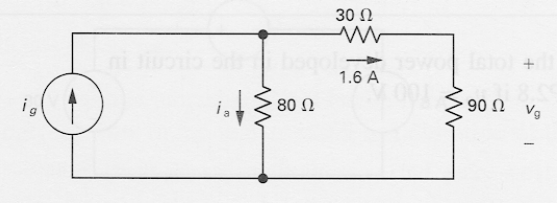
$$p = vi = v(v/R) = v^2/R$$

Note that $p > 0$ always, for a resistor.

Example:

a) Calculate the voltage v_g and current i_a.

b) Determine the power dissipated in the 80Ω resistor.



More Examples

- Are these interconnections permissible?